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Factors For Making Quality Chocolate Mass

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Abstract. Currently, there are possibilities for falsification of chocolate mass making, associated on the one hand with the replacement of raw materials, and on the other hand with a violation of technological processes in production. Therefore, it is necessary to improve the quality control system of incoming raw materials and the production technology.
Keywords: fermentation, heat treatment, conching process, technological processing.

I. Introduction

The confectionery industry is one of the developing branches of the food industry. This article presents materials on the study of the technological stages of chocolate production at the enterprises; it characterizes each stage of the main technological processes, fermentation, heat treatment and the conching process of chocolate mass. The article presents data on the chemical composition of chocolate and the requirements for the quality and shelf life of chocolate masses. Great importance in the article is given to the introduction of more advanced methods of chocolate mass making, which directly affects the quality of manufactured products and makes it possible to produce new types of chocolate products with higher taste qualities and longer shelf life.

Chocolate, the brightest representative of the range of confectionery products, has long been considered a product of everyday consumption. At present, the expansion of the range of chocolate and chocolate products is relevant, because products containing natural additives (candied fruits, nuts, grains of cereals, spices, etc.) are becoming increasingly popular. In addition, in order to reduce the cost of products, manufacturers often replace cocoa butter with an equivalent or improver, which leads to a decrease in the product taste. Technological solutions must be such as to ensure the required quality of chocolate. It is known that the more cocoa products in chocolate, the longer it is stored. Due to the fact that studies on the effect of the content of cocoa products on the safety of chocolate during storage have not been conducted, it is advisable to determine the predicted shelf life. It is especially important to develop, refine and preserve the aroma inherent in cocoa beans which gives chocolate the properties that are incomparable with any other food product. The chemical composition of grated cocoa and cocoa shells is given in Table 1 [1]. To predict the shelf life of food products, various types of mathematical processing are used, however, there are no mathematical models that allow predicting the shelf life of chocolate with a sufficient degree of accuracy. Therefore, the development of models using modern approaches to assessing the quality of chocolate is relevant. To ensure the quality of chocolate, it is necessary to control indices and identifications in accordance with the requirements [2].

Table 1.
The chemical composition of grated cocoa and cocoa shells

Composition components	Composition, %	
	Grated cocoa	Cocoa shells
Water	2,6	5-8

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Fats	54,0	1,4-3,4
Proteins	11,5	13,3-16
Cellulose	9,0	20,4-28
Starch	7,5	3,3-5,1
Polysaccharides	6,0	2,0
Tannins (per dry fat-free substance)	6,0	0,85-1,7
Dyes	5,0	0,5-0,76
Mineral substances and salts	2,0	12,8-17,4
Organic acids and flavors	1,0	0,4
Saccharides and caffeine	0,2	0,15-0,2
Calories	565 kcal	567 kcal

Table 2.
Recipe for control chocolate sample

Ingredient name	Content, kg/1000kg
Granulated sugar	536,74
Cocoa butter	180,62
Cocoa mass	279,59
Soy lecithin	3,98
Vanilla flavor	0,3

The recipe mixture is prepared in universal or other kneading machines with steam and water heating. High-speed five-roller mills are used for grinding chocolate mass. The change in viscosity can be explained by different binding energies of particles in coagulation contacts, which depends on the nature of the substance of the dispersed phase and the dispersion medium, and the energy conditions of coagulation. The strength of cohesion of contacts is significantly influenced by the liquid film, its thickness and polarity.

The process of formation of chocolate masses is determined by the kinetics of the interaction of particles of the dispersed phase through the interlayers of the dispersion medium, i.e., it is determined by surface phenomena at the interface. The magnitude of these interactions, i.e. the number and strength of bonds that arise between solid particles per unit volume of the system determines its structural and mechanical properties, on which, as a result, the technological properties of the dispersed system depend, as well as the quality of the finished product. Effective control of structure formation and regulation of the properties of a dispersed system can be achieved by introducing additives of surfactants, which cause an adsorption decrease in the strength of the structure, facilitating its deformation and destruction. The aroma formation of cocoa beans is significantly influenced by three main stages: fermentation, heat treatment and the process of conching the chocolate masses. Fermentation is the initial stage in the processing of freshly harvested cocoa beans and takes place directly at the harvesting site.

During fermentation, complex processes take place, as a result of which cocoa beans acquire their inherent properties. The fermentation process contributes to the formation of compounds that arise during the further heat treatment of beans and are involved in the formation of the specific flavor of chocolate. It was determined that the completeness of aroma formation depends on the degree of fermentation of cocoa beans.

In the process of technological processing of cocoa beans, an important operation is heat treatment, which results in the appearance of a characteristic aroma, improved taste, color, and the changes in the structural characteristics of cocoa beans. The final, very responsible technological operation is the process of conching the chocolate mass.

Conching is a long-term mixing of the chocolate masses at high temperatures; it is the final processing operation, as a result of which the specific taste and aroma of chocolate are finally formed; it differs significantly from the aroma of non-conched chocolate mass, and from the aroma of heat-treated cocoa beans [3]. The essence of conching is a prolonged mechanical and thermal effect on the chocolate masses in order to achieve the highest organoleptic properties. Visually, this looks like a process of long-term intensive continuous mixing of heated chocolate masses. Modern production technologies provide for double conching: first, dry conching (the mixture consists of grated cocoa and powdered sugar), and then wet conching (cocoa butter is added to the mixture) [4].

II. Research method

Moisture content was measured using the Karl Fischer titration method [5]. The analysis was performed using a 719 Titrino apparatus (Metrohm, Switzerland) with solvent (Riedel-de-Haen, 34812) and titrant (Riedel-de-Haen, 34801). Chocolate samples were preheated at 55°C for at least one hour. To better interpret the texture results, the moisture content of the dark chocolate samples was measured using a NMR instrument in a certain time intervals (Bruker Inc, Germany).

A free decay induction sequence with a time echo of 3 cm was used for the measurements. Mean values were calculated from 3 repeated measurements and standard errors. To determine the water activity, 10.0 g of each chocolate sample was homogenized and 2.0 g of the homogenized sample was used to determine the water activity (aw) at 25°C using a water activity measuring device (Novasina, Switzerland) Lab-Master aw (Standard 1119972). The values for each sample were determined in triplicate 1 day after preparation.

Theoretical viscosity values can be obtained using the Casson and Windhab models. Viscosity according to the Casson model and infinite viscosity are comparable, because the same basic parameters involved in these models are used in the calculations. As is known from the literature sources, Casson plastic viscosity can be used as the infinite shear viscosity of a dispersed system, considering the limiting viscosity at an infinite shear rate. From the Ostwald-Weil model, it can be seen that the viscosity values are given indirectly, for this reason, further processing is necessary to obtain the calculated viscosity value. Applying the Ostwald-Weil effective viscosity model, the following equation was derived

$$\eta = \frac{\tau}{\gamma} \qquad (1)$$

So, substituting equation $\tau = K\gamma^n$ into equation (1), we can obtain the following equation

$$\eta = \frac{K \cdot \gamma^n}{\gamma} = K \cdot \gamma^{n-1} \qquad (2)$$

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where, τ - is the ultimate shear stress, Pa;
η - is the viscosity;
K - is the consistency index, Pa;
γ - is the shear rate, s^{-1};
n - is the dimensionless fluidity index.

Thixotropic values were obtained from the rheological curves of the chocolate samples. During conditioning, a hysteresis loop was formed under a continuous decrease in the effective viscosity and subsequent recovery when the flow is discontinuous. Thixotropy was evaluated according to [6], by the difference between the viscosity measured at 40 s^{-1} slope up (from 2 to 50 s^{-1}) and slope down (from 50 to 2 s^{-1}), multiplied by 402.

Instrumental color determination was performed using a portable colorimeter (Chroma Meter CR-400, Konica Minolta, Japan) that was calibrated using a white reference standard. SCE (Specular Component Excluded) mode values were recorded, and color parameters were expressed in terms of the CIELAB system, obtaining L*, brightness from 0 (black) to 100 (white); a* (from green to red) and b* (from blue to yellow) with values from minus 120 to plus 120. All these values were obtained at 25°C using the CIELAB system. The color parameters in the study were luminance (L*) and chroma (c* = [(a*2) + (b*2)]1/2). All data were expressed as the average of five repetitions conducted on different samples from one batch of each chocolate.

III. Research results

A feature of such studies is the reduction in the viscosity of chocolate masses, as well as the power intensity of the equipment. Conditions for conching chocolate masses are:

1 - compliance with the temperature regime (from 50 to 90°C);
2 - compliance with the duration of processing (from 24 hours to 72 or more);
3 - permanent contact of the surface of the chocolate masses with air.

The results of the procedure for conching chocolate masses are:

- excess moisture evaporates from the chocolate mass and viscosity decreases;
- the remains of volatile, tannic substances disappear;
- solid particles of cocoa are rounded, the consistence of chocolate becomes more uniform;
- taste and aroma improve [5].

Table 3
The results of the analysis of the chocolate mass color

Sample	L*	a*	b*	ΔE
KS	24,50±0,90	5,15±0,20	4,05±0,16	**
KSт	24,20±0,50	3,63±0,37	3,33±0,13	24,43±0,25
KSк	24,37±0,72	3,88±0,33	3,53±0,08	24,15±0,14
KSSк	24,43±0,67	4,25±0,35	4,06±0,18	23,46±0,10
KSSт	24,65±0,45	3,53±0,77	3,15±0,09	24,44±0,14

For each sample of chocolate masses from grated cocoa, a dispersion and multiple comparative analysis was conducted. Taking into account the influence of the sweetener, significant differences in the average values were established by the method of two-way analysis of

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variance. The results of the analysis of variance showed that the effect of the sweetener on the color of the chocolate masses was not significant. From the data shown in Table 2, it is seen that the samples of dark chocolate masses have an average L* value of 24.6. In multiple comparative tests, it was found that all samples were the same in terms of L* values. According to a study presented in [7], dark chocolate samples should have significantly different L* values. This can probably be explained by the fact that the addition of sweeteners leads to an acceleration of caramelization and the Maillard reaction, which affect the color of the chocolate masses. The overall color difference ΔE was calculated using the color values of the various samples of chocolate masses in relation to the corresponding control samples (containing sucrose) taken as a reference. As seen from Table 2, for the dark chocolate masses, the presence of sweeteners did not have a significant effect, except for the sample of the chocolate masses containing sucrose and stevioside. Partial replacement of sucrose with stevioside slightly reduced the color difference. Thus, the studies performed showed that the dark chocolate masses prepared with stevioside showed a preference in the sensory analysis test, showing similar statistical results compared to the control sample with sucrose, and this result was also confirmed by textural and rheological measurements. This allows us to conclude that stevioside can be recommended as a sweetener in the production of chocolate masses with reduced sugar content.

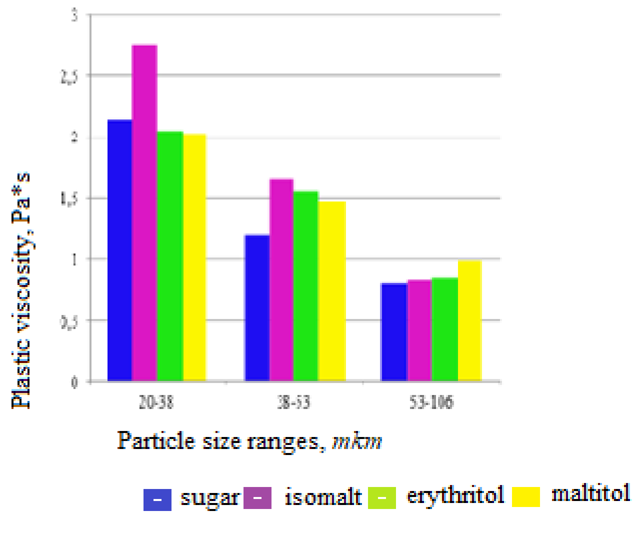

Figure 1. Plastic viscosity of chocolate samples in different particle size ranges

The higher plastic viscosity with isomalt does not appear to be related to its particle size distribution parameters. The particle sizes of isomalt are larger than the sizes of other sweeteners and thus a lower viscosity value for the chocolate masses would be expected based on this. Differences in the particle size of sweeteners within each fraction range make it difficult to interpret the effect of bulk sweeteners and therefore, it is necessary to better control the particle size in these studies. The moisture content of all chocolate samples was almost the same, ranging between 0.60% and 0.73%, and had no effect on viscosity differences. The higher plastic viscosity

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caused by isomalt may be related to its physical properties such as specific surface area, degree of crystallinity and hygroscopicity.

Based on the studies of the color properties of chocolate masses, it can be noted that the use of intense and bulk sweeteners and sugar in chocolate samples containing prebiotic compounds leads to the masses with the closest properties to the control sample.

It was proven that of the studied bulk sweeteners (maltitol, isomalt and erythritol), maltitol is the most preferable, because its introduction into the chocolate masses instead of sucrose provides it with optimal structural and mechanical properties: effective and plastic viscosity, yield strength, flow index.

The color and texture of the chocolate stored at 25°C scored lower than the control and test samples stored at 18°C. When chocolate is stored, fat migration occurs, resulting in fat bloom, which negatively affects the integrity of the product and its appearance. A typical deterioration often encountered with fat migration is the softening and blooming of the top layer of the chocolate, as well as an unacceptable change in the structure of the chocolate in the center due to the migration of the fat phase from the central layers. All this reduces the consumer attractiveness of the product.

Table 4
Characteristics of chocolate made from grated cocoa, stored for 180 days at 18°C and 25°C

Name of the index, point	Index value			
	Control		Test	
	18°C	25°C	18°C	25°C
Color	5,65	3,35	5,16	3,54
Texture	5,84	4,12	5,93	4,50
Taste	5,13	5,23	5,59	5,63
Overall impression	5,15	3,65	5,65	4,12

IV. Conclusion

The study of literature sources on the formation of chocolate aroma showed that aroma is a complex mixture of volatile flavor components (more than 300 compounds) that change during the technological processing of cocoa beans. Under the influence of mechanical and thermal effects, a number of physicochemical and structural-mechanical changes occur in the chocolate masses, which causes a significant improvement in the quality of chocolate, increasing its taste and aromatic qualities. The final formation of the chocolate flavor occurs during the conching process.

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